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GB 2193817 A GB 2140933 A GB 1164064 A
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(54) **Telescopic optical device**

(57) A telescopic optical device takes the form of an optical sighting means OS in which a Galilean principle is employed whereby a positive optically-powered objective lens element OL and a negative optically-powered eyepiece lens element EL are provided. A plastics light waveguide LP, which incorporates a fluorescing medium, is arranged to collect ambient light to illuminate a graticule at an end PT of the waveguide and to inject the graticule into the light path between the objective lens element OL and the eyepiece lens element EL so as to superimpose the graticule on an observer's view through the device. In Fig. 1 a reflective surface RS on the rear of the objective lens element OL is employed for optically injecting the graticule. In another embodiment, Fig. 4 (not shown), a zero or low powered tilted meniscus element (ML) is used. In yet another embodiment, Fig. 5 (not shown), a tilted plane reflector (FR) and an additional positive optically-powered lens element (PL) and an additional negative optically-powered lens element (NL) are used.

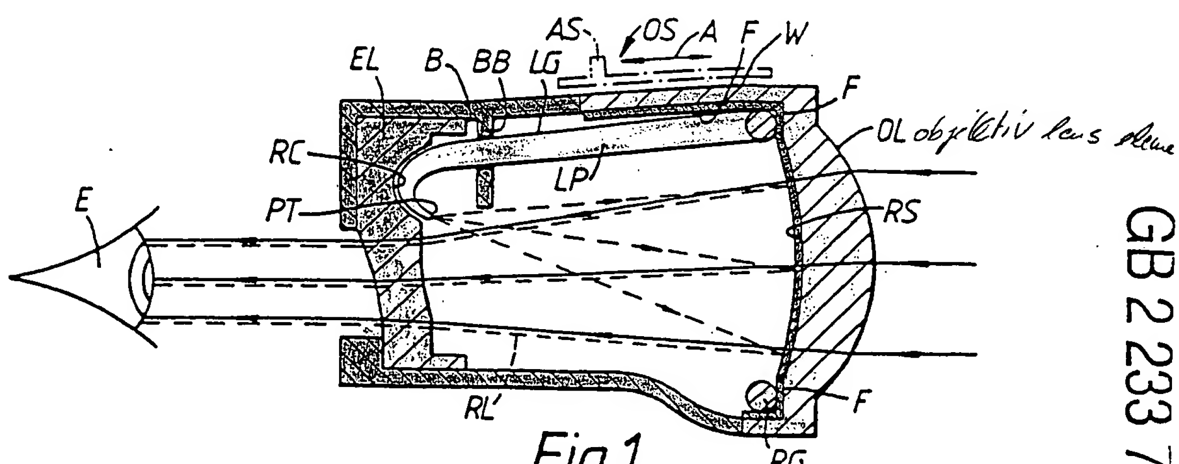

Fig.1.

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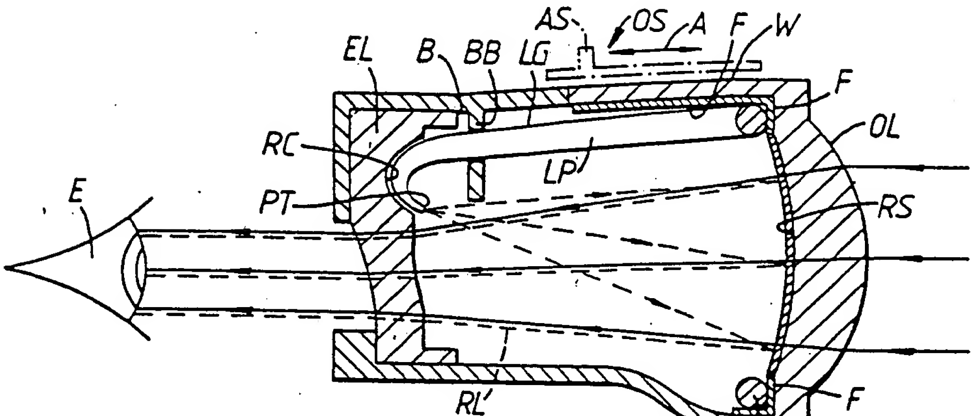

Fig.1.

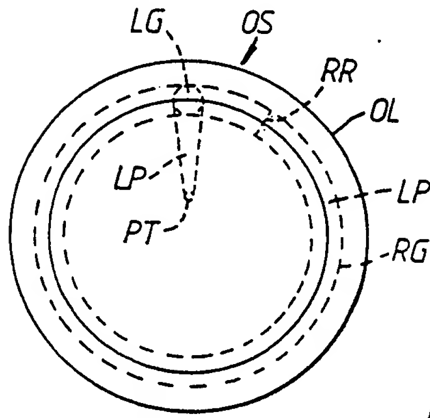

Fig.2.

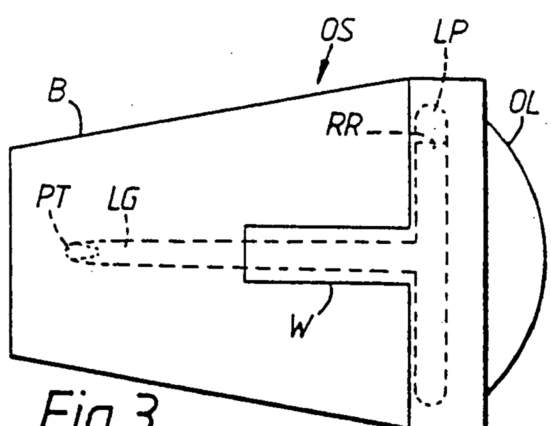

Fig 3

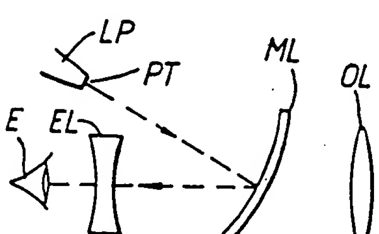

Fig.4.

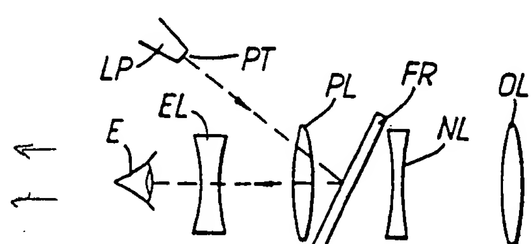

Fig.5.

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TELESCOPIC OPTICAL DEVICE

The present invention relates to a telescopic optical device which finds utility as an optical sighting means, for instance, as a weapon sight.

Known telescopic weapon sights, particularly those employed as rifle sights, normally use a Keplerian form of telescopic optical system comprising an arrangement of two positive optically-powered lens groups. This type of arrangement produces an intermediate image plane at which an obscuration graticule is usually placed for sighting purposes. A major disadvantage of this arrangement is that the intermediate image is inverted and usually requires the inclusion of a prismatic arrangement within the optical system to effect image erection.

Such optical weapon sights have the disadvantages of being expensive and generally have a tendency to be heavy and rather bulky. There is always a requirement to provide less expensive sights and in an endeavour to overcome the above mentioned disadvantages the Galilean form of telescope system comprising a positive optically-powered objective lens group and a negative optically-powered eyepiece lens group has been employed. This has the advantage of not requiring the use of a prismatic arrangement as an erect

virtual image is provided by the two lens groups. Since there is no real intermediate image, the system is unable to accommodate an obscuration graticule and it is necessary to employ a bright injected graticule. Such an arrangement can have the disadvantages of embodying electrically-powered graticule illumination and bulky injection optics.

An aim of this invention is to overcome the aforementioned disadvantages by providing an inexpensive, simple and lightweight telescopic optical device serving as an optical sighting means which incorporates an electrically-unpowered bright injected graticule.

According to the present invention, there is provided a telescopic optical device comprising a body member, objective and eyepiece lens groups, and optical injection means and optical power means arranged for optically-powered injection of a bright graticule into the light path between the objective lens group and the eyepiece lens group so as to superimpose the graticule on an observer's view through the device. With such optically-powered injection the graticule light can approach the eyepiece lens group in a substantially corresponding state to light from a scene or object under view transmitted through the objective lens group. The observer can thus see the bright graticule substantially in focus superimposed on the view of the scene or object.

Preferably the optical injection means comprises a light waveguide incorporating a fluorescing medium which is arranged to collect light to illuminate a graticule located at an end of the light waveguide from which light escapes. The light waveguide preferably incorporates a retro-reflection means, at an end remote from the light escape end.

Conveniently the light waveguide is constituted by a moulded plastics light pipe all or part of which may incorporate a fluorescent dye as the fluorescing medium. Light is arranged to activate the fluorescent dye to provide intensified fluorescent illumination to provide the bright graticule.

The light waveguide is preferably mounted within the device body but may be mounted externally, and is formed in a manner which enables incident ambient light to be collected from the area of regard of the device forward of the objective lens group and also from an area above the device.

Preferably the objective lens group comprises a single positive optically-powered objective lens element and the eyepiece lens group comprises a single negative optically-powered eyepiece lens element.

The rear surface of the positive optically-powered objective lens element is preferably toric in shape but may have a rotationally symmetric surface while the front

surface is preferably aspheric but may be spheric or toric shaped, the precise surface shape being suitable for overall optical correction within the device.

The negative optically-powered eyepiece lens element rear surface shape is preferably toric and may be rotationally symmetric, spheric or aspheric. The front surface shape is preferably aspheric but may also take any of these forms. The particular surface shapes employed depend upon the particular surface shape suitable to operate satisfactorily in conjunction with particular objective lens surface shapes.

The optical power means for injecting the graticule is preferably provided by reflecting the bright graticule from the rear surface of the objective lens element to produce a relayed image of the graticule.

The optical power means for injecting the bright graticule may alternatively be provided by reflecting the bright graticule from a meniscus lens element, located between the objective lens element and the negative optically-powered eyepiece lens element, to produce a relayed image of the graticule.

The optical power means for injecting the bright graticule may also alternatively be provided by reflecting the bright graticule from a plane reflection means located between an additional positive optically-powered lens element and an additional negative optically-powered lens

element of approximate equal and opposite optical power positioned between the objective lens element and the eyepiece lens element, the relayed image of the bright graticule being produced by transmitting twice through the additional positive optically-powered lens element.

The positive optically-powered objective lens element and the negative optically-powered eyepiece lens element rear surfaces are preferably tilted, as are the meniscus lens element and plane reflector means. The positive optically-powered objective lens element, meniscus lens element and plane reflector means may incorporate reflection means which may be a dichroic or partial reflector coating. However a holographic optical element may be employed incorporating compensation arrangements for angle-injected graticule which avoids the need for tilted rear surfaces on the objective and eyepiece lens elements or a tilted meniscus lens element or plane reflector means.

Preferably the light is constituted by ambient incident light, the peak activating wavelength of which is suitably separated (of the order of 100 nm) from the fluorescent light peak fluorescing wavelength to allow light filtration means to be used to prevent fluorescent light escaping from the surfaces of the light pipe material being observed while allowing activating incident light to pass through to the light pipe material.

A dye filter is conveniently employed as the light filtration means which is preferably associated with window means provided to pass ambient incident light into the device.

The window means may incorporate an adjustable shutter moveable to regulate the bright graticule illumination and brightness.

The negative optically-powered eyepiece lens element may be moveable enabling the device to have a variable dioptre setting.

The device may also additionally include electrically-unpowered sources such as tritium and phosphor lamps to activate the fluorescent illumination medium at low ambient light levels.

Preferably the positive optically-powered objective lens element and negative optically-powered eyepiece lens element are each made from optical plastics material such as polymethylmethacrylate.

The invention will be more readily understood from the following description of several exemplary embodiments which should be read in conjunction with the accompanying drawings in which:-

Fig 1 shows a diagram of a longitudinal sectional side-view, through an optical sighting means in accordance with this invention;

Fig 2 shows a diagram of a front-view as viewed in the direction of the objective lens of the optical sighting means of Figure 1;

Fig 3 shows a diagram of a plan-view of the optical sighting means of Figure 1;

Fig 4 shows a schematic diagram of an alternative embodiment according to this invention; and,

Fig 5 shows a schematic diagram of yet a further alternative embodiment according to this invention.

Referring to Figures 1, 2 and 3 of the drawings, briefly the telescopic optical device takes the form of an optical sighting means OS which is ideally suitable as a rifle sight. The optical sighting means employs the Galilean telescopic principle which involves the use of a positive optically-powered objective lens group comprising a single lens element OL and a negative optically-powered eyepiece lens group comprising a single lens element EL.

A bright graticule is injected into the system by means of a light waveguide in the form of a light pipe LP housed within the device. Light from a light source, preferably ambient incident light, is collected by the light pipe LP and the light which escapes from one of the guide ends is directed towards the rear surface of the objective lens element OL which is used as an optically-powered reflective means to produce a relayed image of the bright graticule in the focal plane of the whole objective lens

element (OL). The bright graticule, viewed by the eye (E) of an observer, is overlayed upon the magnified image of the scene viewed through the sight (OS). The rear surface of the objective lens element (OL) is preferably toric, but may be rotationally symmetric, spheric or aspheric. Its front surface is preferably aspheric, but may be spheric or toric.

The reflective means (RS) on the objective lens rear surface may be dichroic or a partial reflector coating depending upon the selected colour e.g. blue, green, red etc of the graticule and the compromise required between graticule visibility and transmission of the optical sight itself. The rear surface of the objective lens (OL) is tilted with respect to the opical axis so that the reflected light is correctly directed towards the eyepiece lens (EL). Image defects in the sight which are produced by the tilted rear surface of the objective lens (OL) are corrected by the use of other tilted and possibly toric surfaces in the objective or eyepiece portions of the sight. In the particular example shown in Fig 1, Fig 2 and Fig 3 a single eyepiece lens element (EL) is employed having its rear surface (the surface nearest the eye E of an observer) tilted in a manner similar to that of the rear surface of the objective lens element (OL).

This rear surface of the lens element (EL) is preferably also toric but may be rotationally symmetric, spheric or aspheric. The front surface of the negative element is

preferably aspheric although a spheric or toric surface may be employed. The particular front and rear surface shapes employed are generally selected on the basis of which is most suitable to operate in conjunction with particular objective lens surface shapes.

Both the objective and eyepiece lens elements are preferably moulded in a suitable optical plastics material such as polymethylmethacrylate (acrylic). The body B of the optical sight in which the lens elements and other parts are mounted is also preferably moulded in plastics material which is opaque. This technique of using moulded plastics components for the respective parts of the optical sight greatly contributes to a reduction in the overall weight of the device relative to metal and glass components.

The agency used to produce illumination for the bright graticule is preferably a known fluorescent plastics material e.g. known by the proprietary name "LISA" in which incident light actives a fluorescent dye which is embodied in the plastics causing it to produce light. Most of this light is contained within the material by means of internal reflection at the surfaces of the material.

The trapped light is propagated along the material (serving as a light waveguide) to emerge at one of its ends only. Thus, an apparent intensification of the incident light occurs which is dependent upon the ratio of the input area for incident light to the output area for the

fluorescent light, less the losses encountered in the material due to e.g. absorption.

Preferably, the peak activating wavelength for incident light and the peak fluorescing wavelength are suitably separated, for example, by of the order of 100 nm, to allow simple light filtration means to be used which prevents the fluorescent light escaping from the surfaces of the material being observed while allowing activating incident light to pass through. In the presently described embodiment, a simple dye filter F provides the required filtering action.

The fluorescent plastics material may be formed into any desired shape and in the presently described embodiment it takes the form of a simple rod or light pipe LP which serves as a light waveguide. The light pipe LP has a circular cross section and is formed generally into a ring shape RG from which projects a single leg LG which tapers to a fine point PT. The free end portion of the leg LG is supported by a bracket BB forming part of the body B and is folded back upon itself so that the fine point end PT, incorporating a suitable graticule, serves as an exit point for the illuminating fluorescent light which produces the bright graticule. The eyepiece lens element EL has a recess RC to accommodate the folded back part. The other end of the rod, in the ring portion RG, incorporates a retro-reflecting means RR which reflects illuminating light within the light pipe LP back along the pipe.

The light pipe (LP) is mounted within the sight body (B) and is generally out of the line of sight through the device, with the ring shaped section (RG) being located immediately behind and around the perimeter of the objective lens element (OL). The leg section (LG) extends backwardly into the sight and part of it lies immediately below a transparent window (W) extending into the opaque body (B) from around the periphery of the objective lens (which window may be moulded integrally with the objective lens element). Conveniently the dye filter (F) is located on this window through which incident light is collected from the area of regard of the sight immediately in front of the objective lens element (OS) and from the sky immediately above the sight through the upper part of the window. This arrangement effects the required filtering in the manner previously discussed.

This arrangement effects a satisfactory and even range of contrast between graticule and sight image since the graticule illumination will react to the brightness of objects in the area of regard of the sight. If necessary a simple adjustable shutter (AS), moveable in the directions shown by the arrows (A), may be mounted above the upper portion of the window (W) to regulate the graticule illumination and, therefore, its brightness.

It is important to appreciate that in order to maintain good real world imagery and not to restrict the field of view to an unacceptably small value, the magnification of the sight should preferably be no greater than about three times.

The invention is not necessarily limited to the fixed dioptre arrangement set by the fixed arrangement of lenses. In fact by arranging for the eyepiece lens element to be moveable, it would be possible to have a variable dioptre setting. Movement of the eyepiece would, however, need to be along a tilted axis as a consequence of the asymmetric nature of the optical surfaces of the lens elements of the sight.

It should be understood that the light pipe LP need not necessarily be completely made in fluorescent plastics material. The portion nearest the graticule which is essentially not employed to collect incident light may be made of a clear optical plastics material (of nominally greater transmission) which is fused to a fluorescent plastics material section which is collecting the incident light.

Additionally to reduce losses of light within the light pipe LP when transmitting it around bends formed in the plastics material, for instance, where the light pipe is formed back upon itself near the free end, simple small moulded prisms may be easily moulded into the plastics light

guide in order that the light is more efficiently transmitted around such bends.

Referring now to Fig 4 and Fig 5, it should be understood that other arrangements for optically injecting the graticule other than using the rear surface of the objective lens element OL may be employed.

In Fig 4, for instance, the graticule can be reflected off a zero or low powered tilted meniscus lens element ML (including a dichroic or partial reflector means) placed between the objective lens element OL and eyepiece lens element EL.

In Fig 5, for instance, the graticule can be reflected off a tilted, plane, dichroic or partial reflector FR placed between an additional positive optically-powered lens element PL and an additional negative optically-powered lens element NL placed between the eyepiece EL and objective OL lens elements. The positive optically-powered lens element PL provides the graticule relay means by the effect of double transmission through this lens while the additional negative optically-powered lens element NL cancels the power of the positive optically-powered lens element PL as seen through the sight.

Graticules may be injected by electrically unpowered sources other than using ambient incident light exclusively. Powered or nuclear devices (such as tritium and phosphor lamps known as BETALAMPS) may be employed. These may be

used in addition to activate the fluorescent illumination medium to intensify the light sources and produce the necessary graticule illumination in adverse ambient illumination circumstances.

It will be appreciated by those skilled in the art that although the objective and eyepiece lens groups of the preferred embodiment incorporate a single lens element each of these lens groups may incorporate more than a single element if required.

It will also be appreciated that while in the particular embodiment illustrated the light pipe LP is shown located within the body B, it may be located on the outside of the body with one end region, incorporating the point PT, entering the area within the body B at a convenient point to enable injection of the graticule.

Finally, it should be understood that the reflective means RS may take the form of a holographic optical element. In these circumstances it would be possible to have the rear surfaces of objective and eyepiece lens elements, and indeed the meniscus of Figure 4 and flat reflector of Figure 5, substantially at right angles to the straight ahead line of sight of the device as partial or total compensation for the angled-injected graticule can be designed into the hologram.

CLAIMS

1. A telescopic optical device comprising a body member, objective and eyepiece lens groups, and optical injection means and optical power means arranged for optically powered injection of a bright graticule into the light path between the objective lens group and the eyepiece lens group so as to superimpose the bright graticule on an observer's view through the device.

2. A telescopic optical device as claimed in claim 1, wherein the optical injection means comprises a light waveguide incorporating a fluorescing medium which is arranged to collect light to illuminate a graticule located at an end of the light waveguide from which light escapes.

3. A telescopic optical device as claimed in claim 2, wherein the light waveguide incorporates a retro-reflection means, at an end remote from the light escape end.

4. A telescopic optical device as claimed in claim 2 or claim 3, wherein the light waveguide is constituted by a moulded plastics light pipe all or part of which incorporates a fluorescent dye as the fluorescing medium.

5. A telescopic optical device as claimed in any one claim from claim 2 to claim 4, wherein the light waveguide is mounted within the device body and is formed in a manner which enables incident ambient light to be collected from the area of regard of the device forward of the objective lens group and also from an area above the device.

6. A telescopic optical device as claimed in any one claim from claim 2 to claim 4, wherein the light waveguide is mounted externally of the body and is formed in a manner which enables incident ambient light to be collected from the area of regard of the device forward of the objective lens group and also from an area above the device.

7. A telescopic optical device as claimed in any one preceding claim, wherein the objective lens group comprises a single positive optically powered objective lens element.

8. A telescopic optical device as claimed in any one claim from claim 1 to claim 7, wherein the eyepiece lens group comprises a single negative optically powered eyepiece lens element.

9. A telescopic optical device as claimed in claim 7, wherein the rear surface of the positive optically powered objective lens element is toric in shape.

10. A telescopic optical device as claimed in claim 7 or claim 9, wherein the front surface of the positive optically powered lens element is aspheric shaped.

11. A telescopic optical device as claimed in claim 8, wherein the rear surface of the negative optically powered eyepiece lens is toric shaped.

12. A telescopic optical device as claimed in claim 8 or claim 11, wherein the front surface of the negative optically powered eyepiece lens element is aspheric shaped.

13. A telescopic optical device as claimed in any one claim from claim 7 to claim 12, wherein the optical power means for injecting the graticule is provided by reflecting the bright graticule from the rear surface of the positive optically powered objective lens element to produce a relayed image of the bright graticule.

14. A telescopic optical device as claimed in any one claim from claim 8 to claim 12, wherein the optical power means for injecting the graticule is provided by reflecting the bright graticule from a meniscus lens element, located between the positive optically powered objective lens element and the negative optically powered eyepiece lens element, to produce a relayed image of the graticule.

15. A telescopic optical device as claimed in any one claim from claim 8 to claim 12, wherein the optical power means for injecting the graticule is provided by reflecting the bright graticule from a plane reflector located between an additional positive optically-powered lens element and an additional negative optically-powered lens element of approximate equal and opposite optical power positioned between the positive optically-powered objective lens element and the negative optically-powered eyepiece lens element, the relayed image of the graticule being produced by transmitting twice through the additional positive optically-powered lens element.

16. A telescopic optical device as claimed in claim 13, wherein the positive optically-powered objective lens element incorporates reflection means.

17. A telescopic optical device as claimed in claim 14, wherein the meniscus lens element incorporates reflection means.

18. A telescopic optical device as claimed in claim 15, wherein the plane reflector incorporates reflection means.

19. A telescopic optical device as claimed in claim 16, wherein the rear surface of the positive optically-powered objective lens element is tilted with respect to an optical axis through the device.

20. A telescopic optical device as claimed in claim 17, wherein the meniscus lens element is tilted with respect to an optical axis through the device.

21. A telescopic optical device as claimed in claim 18, wherein the plane reflector is tilted with respect to an optical axis through the device.

22. A telescopic optical device as claimed in any one claim from claim 19 to claim 21, wherein the reflection means is dichroic.

23. A telescopic optical device as claimed in any one claim from claim 19 to claim 21, wherein the reflection means is a partial reflection coating.

24. A telescopic optical device as claimed in any one claim from claim 16 to claim 18, wherein the reflection means is holographic.

25. A telescopic optical device as claimed in claim 2, comprising light filtration means to prevent fluorescent light escaping from the surfaces of the light waveguide while allowing activating incident light to pass through to the light waveguide.

26. A telescopic optical device as claimed in claim 25, wherein the light filtration means comprises a dye filter which is associated with window means provided to pass ambient incident light into the device.

27. A telescopic optical device as claimed in claim 26, wherein the window means incorporates an adjustable shutter moveable to regulate graticule illumination and brightness.

28. A telescopic optical device as claimed in any one of claims 8, 11, 12, 14, 15, 17, 18, 20 or 21, wherein the negative optically-powered eyepiece lens element is moveable enabling the device to have a variable dioptre setting.

29. A telescopic optical device as claimed in claim 2, comprising electrically-unpowered light sources such as tritium and phosphor lamps to activate the fluorescent illumination medium at low ambient light levels.

30. A telescopic optical device as claimed in any one claim from claim 7 to claim 24 or claim 28, wherein the positive optically-powered objective lens element is made from optical plastics material such as polymethylmethacrylate.

31. A telescopic optical device as claimed in claim 28, wherein the negative optically-powered eyepiece lens element is made from optical plastics material such as polymethylmethacrylate.

32. A telescopic optical device substantially as herein described, with reference to, and as shown, in the accompanying drawing.

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